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CANKER OF APPLE TREES.

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Canker Diseases.—Throughout the fruit growing region of Illinois bark diseases of fruit trees are common. These diseases are popularly known as "cankers." Their injury consists in destroying more or less extended portions of the bark of living trees, thereby causing serious wounds which interfere with the nutrition of all parts of the affected limbs above the canker spot, finally resulting in the death of the limb unless the tree is able to heal over the wound. These diseases are especially dangerous, inasmuch as they do not restrict their injury to a single crop or to one season, but threaten the life of the trees themselves. The diseases are mostly perennial, and having once gained a foothold they progress steadily until they destroy all or a part of the affected trees.

The term "canker" has long been in use in England to designate the irregular and knotty excrescences resulting from the con-

tinued struggle of an injured part of a tree to heal up wounds caused by various agencies as sun-scald, frost, or parasites. In the last case the struggle between the tissues and the parasite continues for many years and large knotty growths are formed at the wounded spot. The European canker caused by *Nectria ditissima* is an example of this kind. In America the term "canker" has come to be a general name applied to all diseases involving more or less extended areas of the bark, although these diseases differ widely in cause and in the effects produced on the host. It is, therefore, a generic term covering a wide range of injuries. So long as this is borne in mind there can be no objection to its use. Moreover it is difficult to replace popular names by others arbitrarily chosen. When, however, it becomes necessary to distinguish between different cankers, more precise names, as "New York apple tree canker" may be used.

Some of the common cankers caused by parasites are described below in order to enable fruit growers to distinguish them and acquire a more accurate knowledge of these diseases. This report is chiefly concerned, however, with a new canker disease which is doing serious damage in the apple orchards of Illinois. This canker is caused by a fungus, *Nummularia discreta*, Tul., which has not been reported as a parasite. In order to distinguish this canker from others it may be designated as the "Illinois apple tree canker."

The best known of the canker diseases is that caused by *Nectria ditissima*. This parasite is common in Europe on beech, apple and other trees. The mycelium kills a part of the bark forming cracks which are partially grown over by the neighboring tissues. The rapid development of the mycelium prevents complete healing and as the process is continued year after year large knots or cankers are produced. In these the wood is laid bare and shows the concentric thick ridges caused by the healing tissues. This canker is not common in the United States.

In New York Paddock investigated a bark disease which he designated as the New York apple tree canker.* By a long series of careful investigations and cross inoculations he showed this disease to be due to the fungus, *Sphæropsis Malorum*, Peck, which causes the Black Rot of the apple. The appearance of the limbs injured by this fungus is various. Paddock describes the diseased limbs as having dark enlarged sections with roughened

*Paddock, W. The New York Apple Tree Canker. N. Y. Agr. Exp. Sta. Bul. 163 (1899) "The New York Apple Tree Canker" (second rep.) do. Bul. 185 (1900).

bark and portions of the wood laid bare. The dead bark clings tenaciously to the decaying wood. This canker is very common in Illinois. The fungus attacks nearly all parts of the tree from the trunk to the youngest twigs. The bark on the diseased limbs at first assumes a dingy brown color and is closely appressed to the wood. It may remain in this condition for a long time, sometimes until the canker spot is nearly a foot in length. Around the margin of the spot the diseased bark is slightly depressed and is separated from the sound bark by a distinct line and often by a narrow crack. Cracks and rifts appear later over the diseased surface and the bark assumes the dark charred appearance characteristic of the canker.

Stewart, Rolfs, and Hall* have suggested the possible connection of *Macrophoma Malorum*, Berl. & Vogl. and of a species of *Cytospora* with canker diseases of apple trees and pear trees.

The Pacific coast canker investigated by Cordley[1] and found by him to be due to *Glœosporium malicorticis*, Cordley, does not occur in this state.

The Illinois Apple tree Canker.

The most serious canker disease in Illinois at present is that caused by *Nummularia discreta*, Tul. This fungus has been known for a long time, but it has never been reported as being the cause of a disease.[2] Its usual habitat, like that of a species closely related to it, is on dead wood. As a saprophyte the fungus has been frequently reported both from Europe and America on dead parts of various hosts. It occurs on the wood of apple, sorbus, cercis, magnolia, and elm. The fungus was first collected in America by Schweinitz, and described by him as *Sphæria discreta*. He frequently found it on the large branches of apple trees. This disease was first observed in this state during the past summer, but it has evidently existed here for some time. It was found to be widespread through the southern part of the state and many individual cankers were found that were at least five or six years old.

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*F. C. Stewart, F. M. Rolfs and F. H. Hall. AFruit Disease Su rvey of Western New York; N. Y. Agr. Exp. Sta. Bul. 191 (1900).

[1]A. B. Cordley. Some Observations on Apple-tree Anthracnose; Bot. Gaz. 30:48. Some Preliminary Notes on Apple-tree Anthracnose. Oreg. Exp. Sta. Bul. 60.

[2]It would seem that this Nummularia must have been observed as a parasite by Tulasne, who states (Sel. Fung. Carp. II, p. 46). "It grows with us during the autumn and winter on *Sorbus hybrida* L. on the thick bark which has recently died."

The following report contains the results of some observations and investigations made on this disease during the past summer. These are as yet in no way complete, but some suggestions as to remedial measures can be given as a result of the work. As the disease is a more serious trouble than is generally supposed, and also to furnish an answer to the inquiries of some fruit growers who have become alarmed about the disease, it was thought best to publish the results thus far obtained.

Inoculation experiments have been begun but it is yet too early to form any conclusions in regard to them.

Distribution of the Disease.

The disease under consideration was found during the past summer in all the apple growing regions of southern Illinois. It appears to be most severe in the orchard regions near Neoga, Salem and Centralia. It was, however, observed also in other parts of the state and it is probable that a closer examination will reveal it in many localities which it has been impossible to examine. When fruit growers begin to recognize the canker better a more accurate knowledge of its distribution will be gained.

Within an infected orchard its distribution is usually scattered, the infected trees occurring here and there throughout the orchard. The fact that it does not seem to spread evenly from a diseased tree to all the neighboring trees would lead to the conclusion that its spread depends upon occasional infections under certain favorable conditions. This will be more fully considered in the following pages:

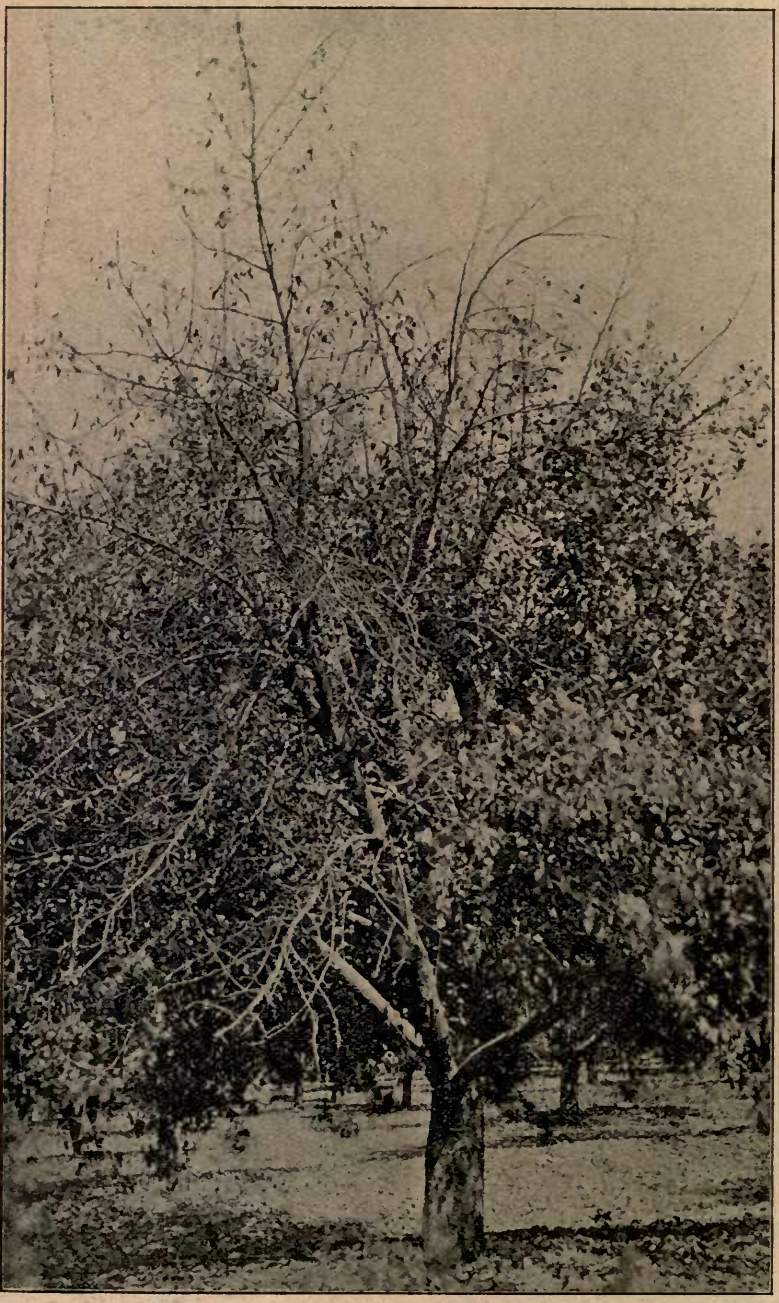
The canker-wounds are usually formed on the large limbs near the trunk of the tree. From here they extend upwards on the limb and frequently down into the trunk. The larger limbs may be attacked higher up in the tree, however. The exact position of the wound depends on the source and manner of infection.

Appearance of the Diseased Branches.

The appearance of the canker varies greatly with age. At first the canker spots are inconspicuous so that they would easily be overlooked by the casual observer. In the earliest stages observed the diseased bark has an unhealthy, dirty brown appearance. It is usually depressed a little below the living bark. The spots vary in size, being sometimes six inches in diameter at this stage. They grow most rapidly in the direction of the long axis of the limb. If the interior of the bark be examined it will be found to have a mottled appearance, due to the interspersion of sound areas

PLATE I.

PLATE II.



within the dead tissues. The boundary between the dead and sound bark is sharply marked. Sometimes cracks appear along this boundary. The dead area is usually a little depressed, due partially to drying and partially to the increase in the thickness of the sound bark. Often the wound is accompanied by a flow of sap or by slime flux. This, however, is probably a secondary phenomenon not due directly to the parasite.

In the late summer or autumn the fruiting stromata, to be more fully described later, appear near the margin of the diseased spot. These are produced under the bark, which soon splits, forming star-shaped ruptures and exposing the pale grayish ochre, spore cushions. These vary from one-eighth to one-fourth of an inch in diameter, rarely exceeding the latter limit. When the stromata are mature they have the form of a more or less irregularly circular disc somewhat depressed in the center, or even cup-shaped. As they are formed in a line near the advancing margin of the canker spot those of the different years come to lie in concentric rows. This appearance is, however, obliterated in the older parts of the canker.

As the canker spot increases in size it changes its appearance. The bark of the older parts becomes much roughened and blackened as if it had been charred. Numerous rifts and cracks appear over the surface of the dead bark, which is very dry and brittle, and falls off in irregular patches exposing the dead wood. The circular stromata are firmly attached to the wood by means of a ring of hard fungous tissue, so that they remain seated on the wood even after the bark has fallen away. The entire blackened area is dotted over with the circular stromata which form the most pronounced distinguishing feature of this canker. The disease is always easily recognized by these stromata, which distinguish it clearly from the New York apple tree canker. Plate I shows two large limbs with old canker spots.

Growth of the Mycelium.

The mycelium evidently extends into the wood of the tree where it grows more rapidly than in the bark. Some limbs were examined at points several feet away from the canker spot and the heart-wood was found to be brown and discolored. It is probable that the fungus can gain an exit where the bark has been broken and form new canker spots at such points.

The effect of the mycelium on the wood and bark has not yet been fully worked out, but some facts may be noted here. The mycelium kills the bark wherever it penetrates, and finally disinte-

grates the cells. It does not advance evenly through the tissues, but leaves islands of sound tissue in the midst of the dead bark. This, of course, is observable only in the young advancing part of the diseased spot, and gives this area the mottled appearance already mentioned. Finally these spots are also killed. The cells of the parenchmya tissue and medulary rays are first attacked. The hard bast fibers resist the action of the fungus and can be seen as glistening groups of cells arranged in concentric rings in the midst of the dead tissue. In the recently killed tissue numerous, very delicate hyaline threads of the fungus can be seen traversing the cells in all directions and sending numerous branches into the neighboring cells. The boundary between the sound and the dead tissues is marked by a very delicate layer of cork cells produced from the parenchmya cells.

Injury Caused by the Fungus.

The injury which the fungus does to the tree is at first only local, being restricted to the area of the canker spot. The death of the tissues here is due to the direct injurious action of the mycelium. The rapid advance of the mycelium prevents the formation of any thick callous or wound-cork on the part of the tree. As a result the cankered limbs remain comparatively smooth and do not form the knotty excrescences observed in the case of nectria canker. In summer a very narrow layer of cork cells, not visible to the naked eye, is formed on the boundary line between the dead wood and the sound tissues. This seems to be the only effort on the part of the tree to stop the advance of the parasite. As the canker spot increases in size the limb shows the indirect effect of the injury. The parts above the injury begin to show want of water and nourishment. The leaves assume a sickly appearance and the fruit remains small. The growth of the fungus is most rapid along the direction of the limb, so that living branches may sometimes be diseased for a distance of two or three feet before they are finally and completely girdled. Such limbs show great want of water and the fruit produced on them is of little value. When a limb is completely girdled all the parts above the canker-spot die. The death of limbs usually takes place in late summer and is to a certain extent dependent upon other conditions. During a dry season limbs begin to suffer and die even before they have been completely girdled; and earlier than during a more favorable season. The growth of the fungus may continue after the death of the infected limb, as the lower part is still in uninterrupted connection with the trunk. Where the canker

spot is near the trunk it rapidly extends down the stem and threatens the life of the tree itself. Plate II shows a condition common in Illinois orchards. One of the largest limbs of the tree has been killed by the canker-fungus.

How the Fungus Enters the Tree.

So far as observations go at present they seem to show that *Nummularia discreta*, like *Nectria* and other fungi of similar habits, is a wound-parasite. Apparently it is unable to gain an entrance into the tree except through a previously existing wound in the bark. The spores which originate in the stromata germinate readily in water, hence when they lodge on the moist surface exposed by a wound their germ-tubes easily effect an entrance into the tissues of the host. Within the tissues the mycelium advances more rapidly in the wood than it does in the bark.

A knowledge of the manner in which the parasite enters its host forms the best foundation for combating diseases of this nature. Too much attention cannot be given to the various causes by which wounds are produced in trees. One of the most prominent sources of infection was found to be through wounds necessarily caused by pruning. Too much stress cannot be laid on the proper pruning of trees; but even if a branch is removed without leaving a stub, the wound still offers a good point of infection for the fungus. Yet such wounds heal rapidly and are less dangerous than the long stubs too frequently observed in the orchards of Illinois.

In one well cultivated orchard it was a noticeable fact that most of the canker spots were situated on the under side of the large limbs near the trunk. In this case it is probable that the injuries were caused by some part of the harness in cultivating the orchard. Often the original wound was entirely obscured by the subsequent action of the canker. It must, however, be borne in mind that the first injury which affords an infection-court may be very slight and easily obscured. Wounds caused by pickers who injure the bark of the trees by climbing about in them also offer favorable points for infection. A case of this kind occurred in an orchard in Neoga, where many of the cankers could be traced to such injuries.

The foregoing cases represent several classes of injuries which are likely to occur in orchards. Of course any kind of injury such as breaking of limbs, twisting and splitting of branches, and perhaps insect injuries will furnish an infection-court for fungi.

Prevention and Treatment.

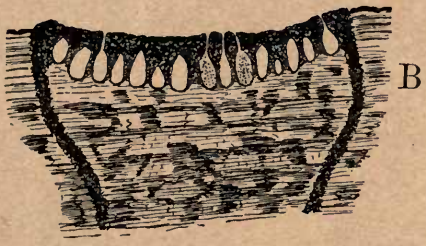
From the nature of the attacks of *Nummularia discreta* there seems to be no method of curing the injury after the parasite has once gained entrance into the limb. The mycelium extends through the wood some distance beyond the injured spot. It is thus well protected within the heart-wood of the tree. If the canker is found in its first stages, however, it may be useful to cut away the injured bark and a portion of the wood and keep the wound covered with Bordeaux mixture or paint. The bark at the edges of the wound will grow out and heal over the injury. Limbs which have extended diseased areas should be removed and burned. When a limb is badly injured it is so weakened that the fruit borne on it is of little value and the death of the limb is only a question of time. Meanwhile every diseased spot is a source of danger to the orchard and cannot be too quickly removed. The canker spots frequently occur near the trunk so that the life of the tree is endangered by them. Infections through wounds caused by pruning can be to a great extent prevented by careful attention to the details of the operation. The indiscriminate and careless cutting of branches frequently practiced in this state is detrimental to the health of the tree aside from the opportunities it offers for parasites of all kinds to enter. Long stubs should never be left on the tree. Limbs should be cut close to the parent branch without making the wound unnecessarily large. Wounds caused by proper pruning heal without difficulty. They should be kept painted or covered with Bordeaux mixture. Injuries caused by climbing about in the trees can be prevented entirely by picking from ladders. There is rarely any necessity for climbing the tree to pick the fruit.

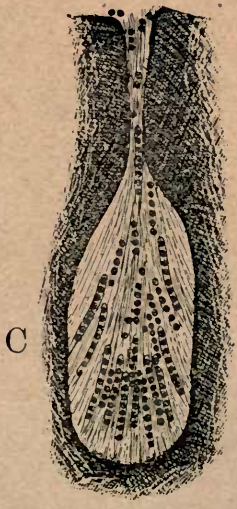
Minute Characters of the Fungus.

The young stromata, as has been stated, appear beneath the surface of the bark. They originate as circular patches of dark colored tissue formed in the bark from numerous closely interwoven fungous threads, Plate III, Fig. A. One of these is called a stroma. On the upper surface of the stroma are numerous erect threads which have very small spore-like bodies or conidia. The conidial layer is at first covered by the epidermis intergrown with fungous tissue, and is not exposed until this fleshy epidermal layer ruptures. The conidia are small, one-celled. Attempts to germinate them have been unsuccessful. Tulasne* figures germi-

*Plate V, l. c.

PLATE III.





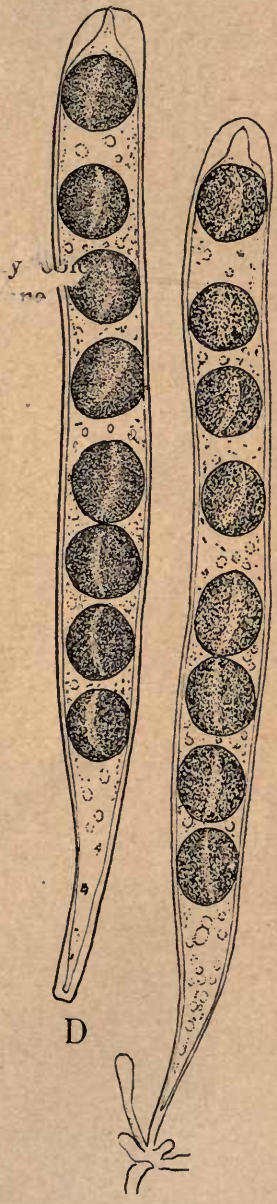
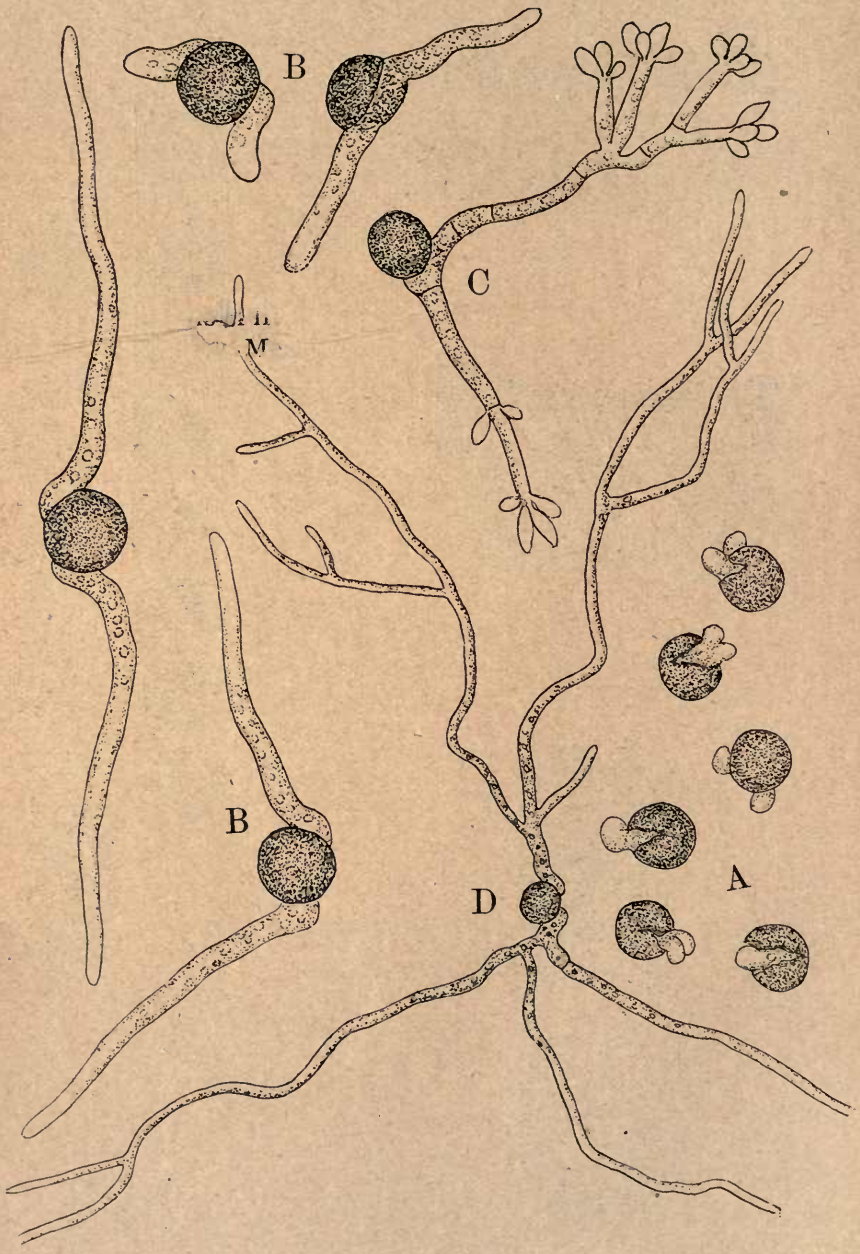


PLATE IV.



nating conidia of this species, and Brefeld* describes the germination of the conidia of *N. lataniaecola*.

As the stroma grows older a ring of black stromatic tissue is formed beneath the disc. This ring extends through the bark into the wood of the limb. The stromatic tissue is hard and resistant, and remains in place after the bark around it has broken loose. In sectional outline the whole stroma is somewhat cup-shaped. (Fig. B). The ring of tissue can be seen as a black circular line in the wood when the stromata are cut off. The upper layer of the stroma at this time contains numerous flask-shaped cavities called perithecia, with long necks opening at the surface. (Fig. C). The spores of the fungus originate within long sacks or asci in these cavities. (Fig. D).

The spores are nearly round or slightly oblong. They are rather large and have a thick brown membrane. Along one side a lighter line can be seen indicating the place where the spore membrane will rupture at germination. The spores are expelled from the sacks and come to lie in little black heaps on the surface of the stromata. It is stated by Tulasne that the spores are expelled in March or April. They may be found on the discs at almost any time. It is probable that many cling there for a year or more.

Spores taken from specimens collected in September germinated readily when sown in water or in beet infusion. If these had been expelled from the perithecia in spring they evidently retained their vitality all summer and for several months more in the laboratory. In germination the exospore cracks along the lines previously described. Two germ tubes originate from the endospore. These turn away from each other and remain at first closely appressed to the spore. Then they grow out in opposite directions. Germinating spores are shown on Plate IV.

The germination of the spores is greatly influenced by their supply of air or oxygen. When many spores were sown in a drop of liquid those which were near the margin germinated readily in 18 to 20 hours, but those which were submerged grew tardily or not at all. In the same manner when the drop was spread out over the slide the spores germinated freely. This may be of significance in connection with the natural coditions under which the spores must germinate and grow.

In some instances the young mycelium before it had grown to any considerable size formed a cluster of branches near the apex,

*Brefeld. Untersuchungen X:256.

and these produced conidia resembling those originating on the young stroma. (Fig. C). More frequently the threads continue to grow and branch freely, forming a very compact colony of mycelium. The growth of the colony is very slow on the media tried. Often long threads grow out from the colony and at their end form a dense brush of branches. None of the colonies fruited in artificial cultures.

Summary.

The common term, "canker," includes all diseases involving portions of the living bark of trees. These may be due to differ ent causes. Pp. 225-226

Several canker-diseases caused by funguous parasites are known in the United States. The most common diseases of this kind in Illinois are the New York apple tree canker caused by the Black Rot fungus, and the Illinois apple tree canker caused by *Nummularia discreta*, Tul. Pp.226-227.

The Illinois apple tree canker occurs on the large limbs and trunks of apple trees. It produces extended blackened areas within which the bark cracks and finally crumbles away. This always results in the death of the affected limb. Pp. 227-233.

The fungus causing the canker is a wound parasite gaining entrance into the tree through wounds caused by pruning or by accidental injuries. P. 233.

The best means of preventing the disease is to avoid as much as possible all injury to the bark, to prune properly, and to paint wounds with an antisceptic solution. Badly diseased limbs should be cut and burned. P.234.

Explanation of Plates.

Plate I., page 229. (A) An old diseased limb, 4½ inches in diameter, showing the stromata of the canker-fungus. (B) Another somewhat larger limb showing earlier stages of the disease. The limb was infected through the wound caused by pruning away a branch. The progress of the disease is marked by the concentric lines of young stromata. At the base of the limb the boundary between the dead and the living bark can be distinguished.

Plate II., page 230. Shows a tree having one of the main branches killed by the canker.

Plate III., page 235. (A) A young stroma of the canker-fungus. (B) A fully developed stroma, showing the perithecia sunk in the upper layer. (C) One of the perithecia more enlarged to show the way in which the spores are borne and expelled. (D) Two of the sacs or asci containing spores. The spores will escape through the pore at the upper end of the sac.

Plate IV, page 236. (A) Germinating spores (×600). (B) Spores more advanced in germination (×800). (C) Condia borne on the young mycelium (×600). (D) Mycelium from a culture 36 hours old, (×385). These threads grow through the wood and bark, causing the death of the tissue.